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The Issues of Commonality Study examines the significant institutional issues related to the acceptance of a concept for the development of a new large cargo aircraft. The proposed aircraft, referred to as the ACMA (Advanced Civil/Military Aircraft), nee C-XX, is conceived as an advanced technology transport with the potential for fulfilling both the U.S. need for military airlift and the worldwide need for commercial airfreight in the 1990s and beyond. There are many political and socio-economic considerations to be		
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addressed when formulating a program involving government and industry participants with their particular and diverse interests. This study focuses on these interfaces and potential problem areas and examines four issues thought to be of more immediate concern to the successful initiation of a joint civilian/military venture.

These issues are:

- o Establishing the Commercial Need, U.S. and International;
- o Development of a Financial Planning Concept;
- o Energy Considerations that May Impact the Program; and
- o Impact of Engine Development/Acquisition.

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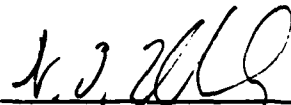
ISSUES OF COMMONALITY

Volume I: EXECUTIVE SUMMARY

LG80ER0013

December 1980

Approved By:



W. T. Mikolowsky, Manager
Engineering Systems Analysis Division

LOCKHEED-GEORGIA COMPANY

A Division of Lockheed Corporation, Marietta, Georgia

FOREWORD

The Issues of Commonality Study was performed by the Lockheed-Georgia Company for the Air Force Aeronautical Systems Division under Contract F3361-78-C-0115. This final study report is presented in two volumes:

Volume I. Executive Summary

Volume II. Issue Analysis

The Air Force program manager was Dr. Larry W. Noggle. Mr. D. L. Bouquet was the Lockheed-Georgia manager for the initial study activities. He was succeeded by Mr. W. A. Garrett during the latter phase of the study.

Lockheed-Georgia personnel who participated in the Issues of Commonality Study include:

J. R. Atcheson	Operations Analysis
D. L. Bouquet	Commercial Need
W. A. French	Propulsion
W. A. Garrett	Program Planning/Financial Management
C. R. Needles	Energy
R. P. Tuttle	Commercial Need
S. M. Williams	Operations Analysis

Program management of the Issues of Commonality Study resided in the Engineering Systems Analysis Division (Dr. W. T. Mikolowsky, Manager) of Lockheed-Georgia.

EXECUTIVE SUMMARY

The concept of a joint civil/military cargo aircraft development program has been advocated for a number of years. Recently, serious interest in the examination of a possible civil/military cooperative airlift development program has been expressed by senior officials within the U.S. Departments of Defense and Transportation. This interest has been prompted by a growing recognition that in a time of increasing costs and diminishing resources, essential improvements in civilian and military transportation system efficiency and flexibility must be explored cooperatively.

There are many important institutional issues related to the acceptance of a joint civil/military development concept due to the numerous and significant interactions between government (both military and domestic agencies), industry (both manufacturers and air carriers), and international aviation interests. These interactions, and the potential conflicts, are the central focus of the Issues of Commonality Study. This report summarizes the work performed to date by Lockheed-Georgia on the Issues of Commonality Study for the Aeronautical Systems Division, Deputy for Development Planning, Air Force Systems Command.

INTRODUCTION

The proposed Advanced Civil/Military Aircraft (ACMA), which until recently was referred to as the C-XX, is conceived as an advanced technology transport with the potential for fulfilling both the essential national security airlift needs and the worldwide economic need for new commercial airfreight transportation in the 1990s and beyond. The essence of the ACMA concept is the premise that the most cost-effective means of satisfying future intertheater airlift requirements is an aircraft designed from the outset to function as both a military airlifter and as a commercial air freighter.

The following paragraphs review the pertinent background, major objectives, and tasks of the Issues of Commonality Study. A broad overview, intended to put in perspective the principal findings of the study, is presented along with the approach used by Lockheed.

Background

The military need for additional strategic airlift capability is demonstrated by the Statement of Operational Need (SON) for an intertheater airlift vehicle issued in August 1979 by the Military Airlift Command. That a substantial commercial market also exists for a long-range aircraft with a payload capability greater than that presently available is suggested by recent NASA-sponsored efforts known as the Cargo Logistics Airlift System Studies (CLASS).

The ACMA concept has evolved in response to these projected needs. The potential benefits of a joint program to both commercial and military users are numerous. Some of the benefits are:

- o Lower average unit flyaway costs for both civil and military users resulting from larger production quantities
- o Amortization of development costs over a greater number of units
- o Greatly increased emergency airlift capability provided by commercial aircraft serving in the Civil Reserve Air Fleet (CRAF)
- o Possible significant cost savings through the reduction in the number of organic military aircraft required

These expected benefits of a joint program should lead to an aircraft that is superior (in terms of cost-effectiveness and profitability, respectively) to any other cargo aircraft available to military or commercial operators.

The concept of a joint civilian-military airlift development program dates back to the 1950s. In the intervening years, interest and support from a variety of sources (DoD, DOT OTA) has gained increasing acceptance, culminating most recently with the validation of the concept by Headquarters, USAF.

Study Objectives and Tasks

The Issues of Commonality Study is a subjective examination of significant non-technical or institutional issues related to the acceptance of a commonality concept for the development of a new, large cargo aircraft that is

capable of satisfying the projected needs of both civilian and military operators. Since aircraft conceptual and preliminary design relating to the ACMA concept are being examined in separate, concurrent efforts, technical design considerations were excluded from this study.

There are many complex political and socio-economic considerations to be addressed when formulating a civilian/military cooperative program because of the diverse and particular interests of the government and industry participants involved. This study identifies and explores these interfaces, their potential problem areas, and examines those issues thought to be of more immediate concern to the successful implementation of a civil/military venture.

The Issues of Commonality Study consists of two primary tasks. The initial task, Phase I, involved a comparative examination of both commercial and military system acquisition processes and the identification of numerous other non-technical, institutional issues—the resolution of which is critical to the successful initiation of a common civil/military aircraft program. Altogether, 16 issues were identified and defined in this preliminary effort. These are listed in Table 1. From these 16 issues, the Air Force program manager selected six issues for more detailed investigation. Following his suggestion, we combined these into the following four principle issues:

- o Establishment of the Commercial Need, U.S. and International
- o Development of a Financial Planning Concept
- o Energy Considerations that May Impact the Program
- o Impact of Engine Development/Acquisition on the Program

A more detailed analysis of significant influences surrounding the resolution of these four issues provided the basis the final phase of the study.

Study Approach

In conducting this study, we solicited opinions and advice from a cross-section of executives within the Federal Government and the aviation industry.

TABLE 1
ISSUE LISTING

1. How will action be initiated to establish a valid basis for documenting and processing the combined civil/military needs.
2. Should an existing federal organization be designated to organize/ manage the program, or should a new organization be established.
3. How to present the program to the Congress and the White House.
4. Establishment of the commercial need.
5. Timing of the program initiation considering possible existing aircraft modifications/derivatives.
6. How to develop mutually-acceptable commercial/military aircraft specification requirements.
7. The development of a financial planning concept for the development, acquisition, and operation of the system including the basis for re-coupment of federally funded R&D cost.
8. How to compensate airlines for a compromised aircraft that reduces profits.
9. Environmental considerations that may impact the program.
10. Energy considerations that may impact the program.
11. How to determine whether the joint civil/military aircraft is a single model or a family of aircraft.
12. International commercial sales.
13. What type of procurement process should be used.
14. Is the engine development/acquisition program a pacing factor.
15. Are changes needed in CRAF procedures to assure dependable response capability for aircraft call-up.
16. What process will be used for the joint airline/military design decisions and control of design changes.

Senior officials from the Office of the Secretary of Defense, the Office of Federal Procurement Policy of the Office of Management and Budget, the Office of the Secretary of Transportation, and the Federal Aviation Agency provided insight into the many complex financial and managerial aspects of a proposed cooperative development program from the Government viewpoint. Invaluable assistance was obtained from consultations with senior corporate staff officials from major U.S. commercial air carriers, airport planning authorities, and the senior financial staff within the Lockheed Corporation. The principal offices contacted are listed in Table 2.

Each of the issue analyses in this study depends heavily upon the expertise of senior executives representing specific interests in over 65 offices in the airlines, the military, and the various government agencies. The contributions of each of these executives are significant and extremely important in providing a better understanding of the many and often complex factors influencing the initiation of a joint program.

OVERVIEW OF FINDINGS

The highlights of our more detailed examination of the four institutional issues selected by the Air Force project manager are provided below.

The Commercial Need

The joint development concept is inherently dependent on the existence of a credible market for a civil version of the aircraft. During consultations with senior airline officials, we found a considerable base of support within the airline industry for the concept of a joint civil/military airlift development program. There are, however, differing views on the size and capabilities of the aircraft desired.

Our examination of the available cargo market forecasts did not provide the necessary credible basis for establishing the potential size of the civil market for a new advanced technology cargo aircraft in the late 1990s and beyond. However, a compilation of forecasts prepared by aircraft manufacturers, airlines (both domestic and international), and other organizations,

TABLE 2
GOVERNMENT/INDUSTRY CONTACTS

<u>FEDERAL GOVERNMENT</u>	
<ul style="list-style-type: none"> ● Office of Federal Procurement Policy/OMB ● Department of Defense <ul style="list-style-type: none"> - Office of Secretary of Defense - Joint Staff, Joint Chiefs of Staff - Air Staff, Headquarters U.S. Air Force - Military Airlift Command - Aeronautical Systems Division, Air Force Systems Command ● Department of Transportation <ul style="list-style-type: none"> - Research & Special Programs - Transportation Systems Center - Federal Aviation Agency ● NASA Headquarters <ul style="list-style-type: none"> - Langley Research Center ● Legislative Branch 	
<u>STATE/COUNTY GOVERNMENT</u>	
<ul style="list-style-type: none"> ● Hartsfield International Airport, Atlanta, Georgia ● Dade County Planning Commission, Miami, Florida 	
<u>INDUSTRY</u>	
<ul style="list-style-type: none"> ● American ● Continental ● Delta ● Eastern ● Flying Tigers ● Northwest Orient 	<ul style="list-style-type: none"> ● Pan American ● Seaboard World ● TransAmerica ● Trans World ● United ● World Airways

shown in Figure 1, normalizes these projections to a common basis and depicts their boundaries. There is general agreement among those we consulted that a real commercial need exists for a new cargo aircraft to satisfy the projected growth in the air cargo market in this time period. The main question remains the actual size of the U.S. and international market.

The potential commercial market for an ACMA must be verified at successive points in the program planning cycle, with progressively increasing confidence, as a basis for proceeding to a specific acquisition plan. The ultimate successful initiation of a joint civil/military development program will be strongly dependent on the projected number of commercial sales and the timing of commercial deliveries relative to military need dates. Among the contacts we made, the predominant feeling is that the success of such a cooperative venture will be heavily dependent upon the degree of influence permitted the civil sector and whether they will be allowed to participate on an equal partnership basis with the military.

Financial Planning Concepts

The driving force for the initiation of a joint civil/military development program is based primarily on the military need. However, the dynamics of the current socio-economic-political forces and the increasing competition among Federal agencies for major funds have focused attention on the need for increased dependence upon civilian airlift capabilities to meet national defense airlift needs. Additionally, the magnitude of the development task and the near-term financial situation of the U.S. aviation industry precludes program accomplishment on a timely basis solely by private enterprise. But, as we have noted, there is substantial evidence supporting the growing commercial need for a new large air cargo airplane which, with expected improvements in system economics, can provide the much needed stimulation of the air cargo market.

Our consideration of potential financial planning concepts began with an examination of both current commercial acquisition practices and the military system acquisition procedures. We found that the normal development and acquisition processes for commercial transport aircraft differ in many aspects

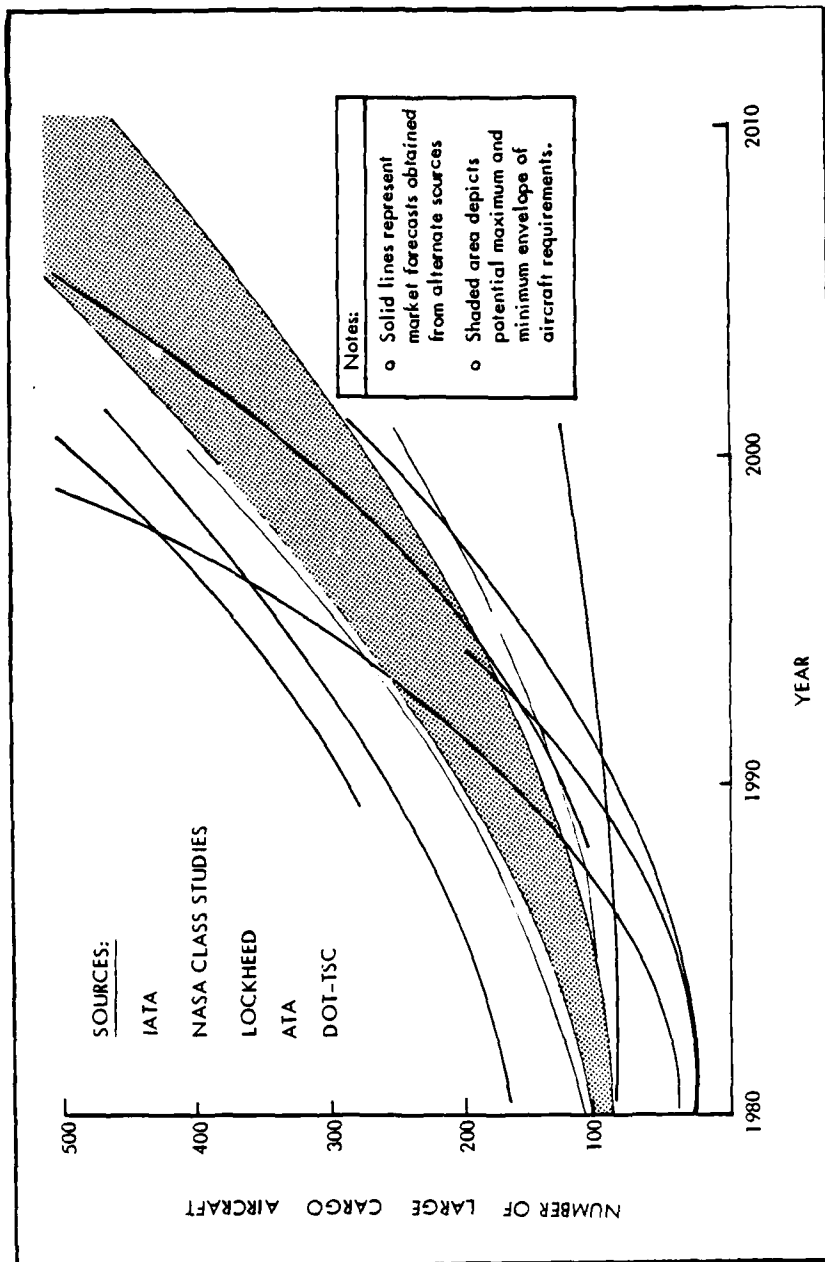


Figure 1. Free World Market Forecasts

from the process used by the military. When economic conditions indicate a need for new commercial equipment, the competitive forces interact until a realistic program evolves. This informal process involves securing orders for a sufficient number of aircraft which, supported by financial commitments, warrants initiation of a production program.

Military acquisition procedures are more formal and structured than the commercial process. A precise description of a perceived military operational deficiency initiates the process. Then a thorough analyses of functional requirements for the system provide the basis for the establishment of the final system design specifications. The development process for a military system is closely monitored by senior management within the DoD and Congress throughout the development and acquisition phases of a program.

Any major program initiative in which the Federal Government is expected to play a primary role will likely be governed by the acquisition policies outlined in OMB Circular A-109. This led us to develop a detailed representative program planning schedule following the guidelines and principles outlined in this circular and the DoD implementing directives. Experience gained during several recent major weapon system acquisition programs provided the basis for projecting the time sequence of specific developmental phases. Initial drafts of the representative planning schedule were reviewed with senior officials within the DoD and OMB. A summary of the schedule is shown in Figure 2. The chronological order of various detailed program actions/activities generally reflects a consensus of these key staff representatives. The representative program planning schedule serves to identify the major development activities, their related timing, and certain specific actions which are clearly the responsibility of the DoD.

Government Financing - Since the primary motivation for pursuing a cooperative development concept is based on a fundamental requirement to provide augmentation to the U.S. outsize emergency airlift capability, we foresee that all funding for the conceptual and validation phases will be provided by the Government. This view was shared without exception by the carriers contacted. Assuming the final design configuration is tailored to meet the demands of the air cargo market, it is anticipated that government and industry will share

the cost of the full-scale engineering and production phases. The formula for joint participation will be considered at an appropriate time during the early development phase.

It is envisioned that federally funded R&D costs would be recouped for commercial production aircraft and, at the time of go-ahead, the R&D costs would be added to the planned production program on a pro rata basis. Federal funds would be recovered on a ratio of commercial to total production. In the event the planned program production is exceeded, the Government would recoup a greater percentage of funds with the potential of eventually making a profit. The rates of recoupment per unit production after the initially planned program would be subject to negotiation and the overall economic conditions of the competitive market. If the initially planned production was not accomplished, the government recoupment would be less. The risk associated with the different outcomes would be analyzed before go-ahead.

Private Financing - Consultations with the many senior representatives of the major carriers and the senior Lockheed financial staff provide the basis for the findings summarized below:

- o Significant contributions from private industry are appropriate and obtainable.
- o Commercial financing is available to air carriers for purchase of large cargo aircraft that can be operated profitably.
- o Potential improvements in system economics could avoid the need for government guaranteed low-interest/no-interest loans or subsidy to carriers for purchase of the aircraft.
- o Development of a system with significant competitive advantages in terms of direct operating cost (DOC) and energy efficiency could be highly attractive to both U.S. and international operators and investors and could reduce the level of federal funds required for program success.
- o Initial industry funding during the validation phase would provide a gauge of commercial interest. Cost sharing may be the best means to gauge industry's faith in the proposed program objectives and also be most convincing in selling the program to Congress and the public.

- o Commercial financial participation may be directly related to the degree of influence exercised by commercial interests during the system definition phase.
- o Industry's share of additional development and program costs is to be based on further study of risks involved.

International Participation - It is believed the concept of a joint government-industry program for the development of an advanced technology cargo aircraft system will be attractive to international carriers. An initial summary of findings pertaining to potential international participation is shown below:

- o An advanced technology ACMA with improved commercial economics can be expected to be attractive to international carriers.
- o Potential international sales could represent up to two-thirds of total market.
- o Off-set will be a major consideration in international sales.
- o Joint venture between the United States and foreign countries could involve both manufacturing and investment capital.
- o International carriers can be expected to obtain financial support from private in-country sources.

We should also note that many observers believe that direct international participation is essential to the success of a joint civil/military transport program.

Energy

Energy is one of the primary concerns of the transportation sector today. For that reason, this study investigates the energy considerations that might impact the development of a joint civil/military cargo aircraft for the 1990s. The areas addressed include future availability of conventional fuels, alternative fuels, and fuel-conservative engines. These areas were then evaluated in terms of their potential for energy conservation in future commercial and military air cargo operations.

As shown in Figure 3 the military strategic airlift and commercial air cargo usage represent only a small part of the total U.S. consumption of petroleum. This fact, coupled with the total dependence of aviation on liquid fuels, forms the environment in which the air transportation mode must compete for diminishing petroleum-based fuel supplies.

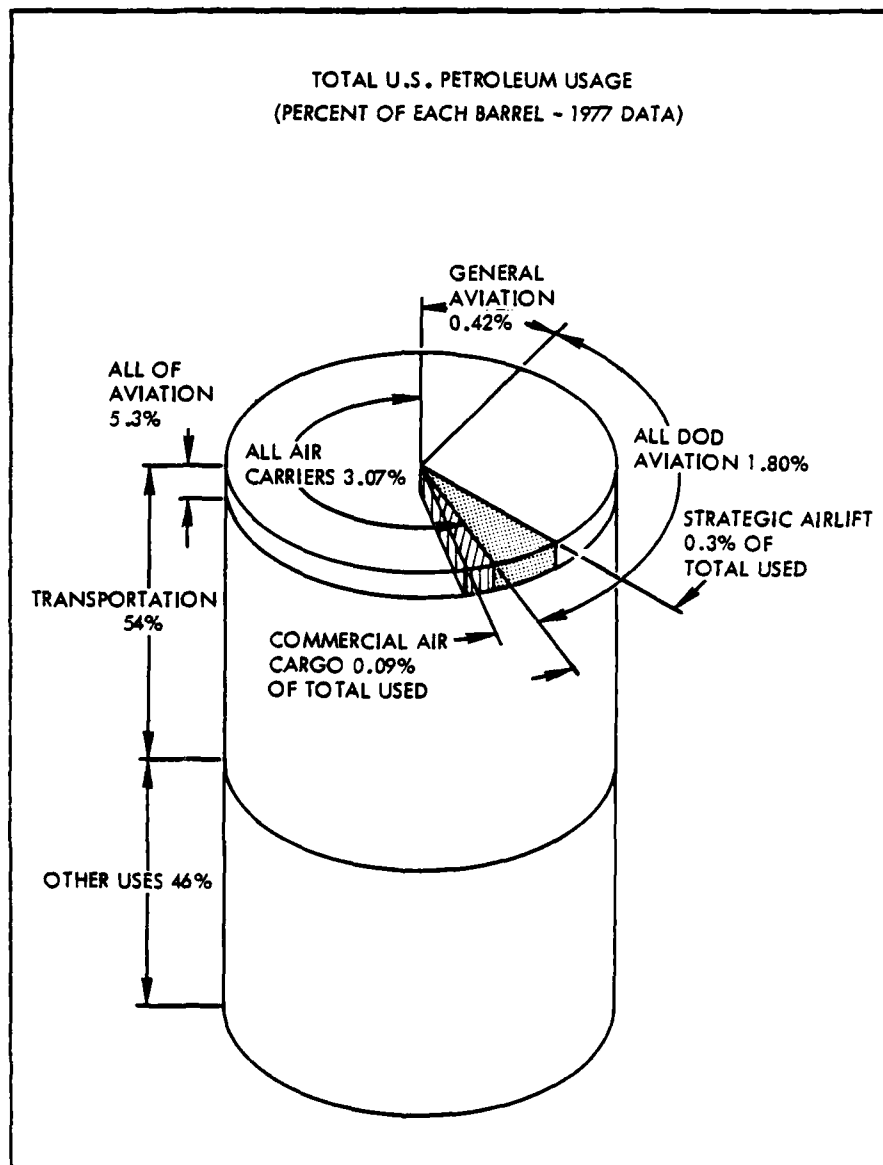


Figure 3. Commercial Air Cargo and Military Strategic Airlift Petroleum Usage

Most assessments agree that world oil production is nearing its peak. World coal reserves, though, are estimated to last for the next 400 to 500 years. Many alternatives to petroleum fuels exist and are possible candidates for satisfying future aviation requirements. Among the most attractive choices are liquid hydrogen, liquid methane, and synthetic fuels from oil shale, coal, or tar sands. Each has its advantages and disadvantages in terms of cost, weight, energy content, and environmental impact. For the 1990s, liquid fuels derived from oil shale and coal feedstocks are generally believed to be the logical replacements for petroleum-based fuels.

When we began this investigation of the energy issue we asked the question: "Will it be in the public interest to develop a new air cargo transportation system for the 1990s in view of escalating fuel prices and diminishing domestic fuel supplies?" We now feel that the answer to that question must be "Yes." Since fuel costs are occupying a larger and larger part of direct operating costs, if the air cargo industry is to continue to operate profitably it must carry more cargo on less fuel. Certainly from an energy standpoint alone, any aircraft that could accomplish the same mission on substantially less fuel would be an attractive investment to any air cargo operator.

There are many energy conservation options that may be incorporated into the design of the next airlifter. When compared with contemporary cargo aircraft, a 1990s airlifter in civilian or military roles could offer increased payload capability and substantial fuel economy using the technology available today or the technology expected in the near future. Optimum energy efficiency, though important, is still but one of many design considerations and should not, therefore, be viewed as the primary ACMA design criteria. In the final analysis, total economics will govern the design of the 1990s civil/military airlifter.

Engine

Our examination of this issue focused on the potential size and type of engine required for the ACMA and the level of propulsion technology available to meet a 1995 initial operational capability (IOC). Both technical and nontechnical

influences were considered in a generally qualitative manner. The engine size required will be dependent upon the take-off gross weight of the aircraft, its desired performance characteristics, and the number of engines. In addressing this issue, we developed preliminary estimates of the size of the engines needed based on rated thrust or shaft horsepower required for representative weights of the ACMA. A survey of engine manufacturers assessed the status of current propulsion technology development programs. Various engineering and advanced technology engine studies being conducted both within the industry and by the industry under government sponsorship were also examined. The exploration of the potential impact of technology improvements on fuel efficiency was a key consideration in these surveys.

Since current airfield runway design criteria will limit aircraft gross weight to approximately 1,000,000 pounds for the foreseeable future, our findings indicate that derivatives of today's large turbofan engines may be suitable for use on the ACMA. Alternatively, advanced technology engines resulting from the Energy Efficient Engine (E³) demonstrator program currently being developed by General Electric and Pratt and Whitney under contract to NASA, offer significant improvements in reduced specific fuel consumption (SFC) and in direct operating cost (DOC). Present indications are that the prototypes of these engines should be available by the end of the 1980s and should be considered as primary candidates for the ACMA development program.

SUMMARY OBSERVATIONS

Our work to date on these institutional issues suggests that a broad base of support exists for the acceptance of the commonality concept as a viable solution to the problem of developing a cost effective and flexible national airlift capability. Furthermore, recognition at the highest government levels that the military is increasingly dependent upon civilian airlift resources to meet growing defense mobility needs provides a convincing basis for further serious exploration of a civil/military airlift development effort. Additionally, substantial evidence exists which supports the commercial need for a new large cargo transport to satisfy the projected growth in the world air cargo market in the late 1980-1990 time period. Nonetheless, the size of this projected market is uncertain.

Other observations indicate that the magnitude of the costs for such a program will necessitate government funding for the research and development activities. These R&D costs would be prorated and recouped for commercial production aircraft based on a planned production program. The development of an air cargo system with significant competitive advantages in terms of direct operating costs and energy efficiency could be highly attractive to both U.S. and international operators/investors and could reduce the level of federal production funds required for program success. Commercial financial participation may be directly related to the degree of civil influence exercised during the system definition/design phase. Since the potential international sales of such an aircraft system could be very significant, the possibility of a joint venture must be considered.

In March 1980, the Office of Technology Assessment (OTA) completed a broad examination of the principal factors that are likely to influence the evolution of air cargo transport in the future. Among other things, they found that:

- o The incentive to design and build a new aircraft specifically for the commercial air cargo market is currently inadequate to justify the investment risk and will probably remain so for the rest of this century.
- o The technology involved in lowering the cost and improving the performance of passenger aircraft are equally applicable to cargo aircraft.
- o The most likely possibilities for an advanced technology, long range (intertheater) military cargo aircraft are adaptations of new passenger aircraft or a joint civil/military development.

OTA further concludes that while there are several cargo aircraft development program variants possible, the logic and potential economies of a joint civil/military program are sufficient to justify further evaluation.

In closing, we would like to point out that, almost without exception, the concept of a government/industry cooperative development program has stimulated the imagination of all those we contacted. While there have been a few skeptics, the overwhelming majority hold the view that the successful initiation of such a program represents a challenging, yet attainable goal.

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